of ascent and the falling velocity of these has been determined, so that placing the plane in any given situation enables the upward current to be determined. Measurements have been effected up to 4 kilometers, and enough material has been accumulated to enable general conclusions to be derived as to the intensity, vertical extent, and the cause of vertical movements in relation to heat conditions, vertical distribution of horizontal wind velocity, and weather conditions.

Doctor Raethjen, whose health has now given way, developed an extraordinarily accurate kinematographic measuring apparatus for following from two bases the flight of a soaring plane or small balloon.

In the study of streamlines in the free atmosphere, pilot balloons with no lift are carried up by airplane and released at definite places. This work is being extended to the study of turbulence.

The work of the institute is being greatly handicapped by the present financial situation in Germany. The subsidy from the State was reduced one-third in 1929, and three of the scientific posts had to be allowed to lie vacant.

METEOROLOGICAL CONDITIONS DURING THE FORMATION OF ICE ON AIRCRAFT[1]

By L. T. SAMUELS

[Weather Bureau, Washington, D. C., Dec. 1932]

(Author's abstract)

Ice is found to collect on a plane in appreciable amounts only when the plane is in some form of visible moisture such as cloud, fog, mist, rain, etc., and the air temperature is within certain critical limits. There are two principal types of ice formation found under such conditions, viz, clear ice and rime. Of these, clear ice forms the greatest hazard in that it adheres more firmly to the plane and decreases its lifting qualities markedly. A third type, viz, frost, is of lesser importance, as it has very little resistance to the vibration and wind force encountered in flight.

The records of ice formation obtained at four Weather Bureau airplane stations were classified according to the two general types of formation, viz, clear ice and rime, together with the respective temperatures, relative humidities, clouds and elevations above ground at which the formations occurred. This classification includes 108 cases where rime formed, 43 cases in which clear ice formed and 4 cases when both rime and clear ice formed during the same flight.

It is found that both clear ice and rime formed over practically the same range of temperature, viz, 0° C. to −18° C. and 0° C. to −20° C., respectively, showing that temperature alone can not be used as a criterion for indicating which type of formation will occur on any particular occasion. It is thus concluded that one or more other factors are decisive in determining the type deposited.

The temperatures at which the most frequent deposits occurred were higher for clear ice (−4° C. to −5° C.) than for rime (−6° C. to −7° C.). These values agree closely with those found by Peppler (1) from kite observations. The latter indicated that clear ice formed at an average temperature of −4° C. and rime at −6° C. It is found that 58 per cent of the total number of clear ice formations occurred at temperatures at or above −5° C., whereas only 37 per cent of the total number of rime formations occurred over this temperature range.

A very pronounced maximum frequency of occurrence of both clear ice and rime was found at relatively low heights, viz, between 500 and 1,000 meters above ground. Secondary maximum frequencies were found between 2,500 and 3,000 meters for clear ice and between 4,000 and 4,500 meters for rime. These primary and secondary maximum frequencies of occurrence are possibly related to layers of maximum condensation (cloudiness). Both types of formation occurred throughout the same strata and with small and practically equal percentages of frequency at the lowest and greatest heights reached. The maximum heights where icing occurred coincide with the maximum heights of the flights.

Both clear ice and rime formed most frequently in St. Cu. clouds. Comparatively high percentage frequencies of clear ice formations occurred in A. St. clouds, and of rime in St. clouds; when in rain, but not in cloud, the formation was always clear ice.

An examination of the prevailing temperature lapse rates occuring in these observations showed no relationship between the lapse rates and the type of ice formation.

The ratios between the number of occurrences of rime and of clear ice deposits vary considerably for the four stations used. This ratio for the observations for all stations combined was 2.5 to 1.0, with a preponderance of rime. These ratios (rime: clear ice) for the individual stations are as follows: Chicago, 1.7; Cleveland, 7.5; Dallas, 5.5; and Omaha, 0.6.

It seems probable that, in general, large droplets tend to form clear ice, whereas small droplets usually produce rime. Small droplets, in general, freeze more rapidly than do large droplets.

The resultant effects of partial freezing, evaporation, and rate of conduction of heat away from water deposits on the plane appear to be of prime importance in determining the type of deposit.

The suggestion by various authors that supersaturation with respect to ice in clouds composed of subcooled water droplets is responsible for comparatively sudden and heavy ice deposits as occasionally reported by pilots is shown by Humphreys (2) to be inadequate. If we assume a condition of supersaturation with respect to ice at a temperature of −10° C., and if all the excess vapor in the air were deposited on the plane, it would be equivalent to a layer of clear ice 1 inch thick on the front of a plane after the latter had flown for a distance of 72 miles. Furthermore, it is probable that only a small part of the excess vapor encountered would be deposited on the plane.

In connection with the occurrence of undercooled cloud droplets at low temperatures it is noted that A. Wegener (3) observed a "fog bow" in Greenland at −34° C.; also, W. C. Haines (4) observed rime formations in the Antarctic produced by fog at temperatures of −26° C., −30° C., and −44° C. The manner in which water exists in the liquid state at such low temperatures is not fully understood.

The results of this investigation show that the danger of ice formations can be avoided only by avoiding visible moisture, particularly liquid water clouds or rain, when the temperature is at or below freezing.

One of the chief difficulties in a study of this kind is the frequent impossibility of determining which type of

[1] Complete paper published by National Advisory Committee for Aeronautics Technical Note No. 439. Washington, D. C., 1932.

ice formed, since most of these flights were made before daylight and the ice usually was melted by the time the plane reached the ground. Also, there is a certain amount of confusion in the minds of many as to what constitutes rime and what clear ice. It is hoped that the descriptions given in the paper will make possible a more accurate classification in this respect in future observations. It is believed, however, that so far as averages are concerned, the values found would not change appreciably with additional observational data.

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THE SECTION DIRECTOR AND THE COOPERATIVE OBSERVER[1]

By M. E. BLYSTONE

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I have chosen as the title of the paper, "The Section Director and the Cooperative Observer." This title would seem to involve practically all the activities of the Climatological Service, and probably nearly all of them will be touched upon in some part of the paper in the hope that some of my experiences and possibly some of the methods of handling the work at Huron may prove helpful to other section directors. There is also the hope that in the discussion to follow some things will be brought out that will be helpful to me. However, it will deal mainly with matters pertaining particularly to the personnel.

It seems to me that the most important functions performed by the Weather Bureau, next to that of making and disseminating forecasts and warnings, is that of securing a climatological history of the country. The aim of each section director, to voice a thought which, doubtless, every one of them has before him at all times, should be to make this history as exact and reliable as possible. In the aggregate, large interests are involved in this connection. Court decisions and the friendly settlement of damage claims are often determined by the weather records. Whether climatic conditions are favorable or unfavorable for the type of farming in which prospective settlers contemplate engaging is shown largely by the climatological history obtained through the efforts of cooperative observers. This is true of all the country, but it is particularly true of the more sparsely settled States like South Dakota.

It is as much the duty of the Weather Bureau to show that climatic conditions are unfavorable when such is the case as it is to show that they are favorable. Also, in some instances, the practicability of carrying on other industries than farming is determined by the climatic conditions that prevail. That justice may prevail in court decisions and in the friendly settlement of differences; that the development of agriculture, particularly in new territory, may be along proper lines; and that the peculiar climatic conditions needed by certain lines of manufacture or other industry may be determined so that they need not be artificially produced, thus avoiding economic loss, reliable data are necessary. Thus a great responsibility rests upon the section director and, through him, on the cooperative observers. Careful and conscientious direction of the work of cooperative observers by the section director can bring valuable results, while lack of it may bring loss to those placing reliance on the accuracy of the data. The thing of first importance in the service, therefore, is to secure a corps of intelligent and reliable observers, men or women, who take a personal interest in making weather records and can be depended upon to make them trustworthy and to whom anything other than truth in their records would be odious.

In what class of persons can the most desirable observers be found? This is a question that is difficult to answer. Probably section directors have varying opinions regarding the matter, based, of course, upon their varying experiences. First of all I want to eliminate school-teachers. My experience is that they are undesirable. Their first purpose in acting as observers is to have the use of the equipment in teaching a small amount of meteorology to their science classes. This, in itself, of course, is good, but the purpose of maintaining the climatological service is to record climatological history, not to teach meteorology to high-school students. The teacher is apt to delegate the taking of observations to students, one at one time and another at another time, with undesirable results, for few of them comprehend the reasons for the work or care for it beyond getting by. Furthermore during vacation periods it is probable that no observations at all will be made.

It has been my experience that intelligent farmers of some education who possess a liking for noting and recording weather facts make excellent observers. Their personal interests are involved in securing a reliable climatological history of their localities. Also they are located out in the open where they can observe and make note of facts regarding the weather that are not so apparent to a man in town. If the equipment is properly placed on a farm, the data are less likely to be affected by local conditions than if the equipment is in town. When inspections are being made, some inconvenience is encountered and some additional expense is incurred if the station is in the country, particularly if the section director is traveling by train and not by automobile, and these facts deserve consideration. However, if a farmer who is acting as observer lives near town these considerations are minimized. On the whole I prefer farmer observers to any other class. When in need of a new observer my practice is to try to secure an intelligent farmer who lives near town and who is interested in that sort of thing. This is not to say that excellent observers are not found in other lines of employment. We have many excellent observers in South Dakota who are not farmers.

Probably every section director has, at some time or other, wished that cooperative observers were paid for their services so that pressure could be brought to bear on them to induce them to render prompt and complete reports. Doubtless, however, the attitude of the central office in this matter is wisest, for if no observer who is desirable because of his intelligence, reliability, and interest in the work can be secured without pay, the small compensation that could be given probably would not

[1] Invited paper presented before American Meteorological Society, Des Moines, Iowa, Dec. 28, 1929.